EXPERIMENTAL USE OF POLYESTER FIBER MODIFIED BITUMINOUS PAVEMENT ON VERMONT ROUTE 12A

Initial Report 82-7
August 1982

REPORTING ON WORK PLAN 81-R-15

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

T. EVSLIN, SECRETARY OF TRANSPORTATION
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Reviewed By:

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R. F. Nicholson, P.E., Materials & Research Eng.

Date: Aug 19, 1982

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TABLE OF CONTENTS

Abstract. 1

Introduction 2

Product Information 3

Project Description and Roadway Condition. 6

Mix Production and Testing. 7

Paving Operation 8

Post Construction Observations 9

Summary 12

Recommendations 13

Appendix A

Manufacturers Cost Saving Estimates 14

Appendix B

Original Pavement Condition - August, 1981. 15

Appendix C

Mix Design and Laboratory Test Results 17

Appendix D

Test Section - Plan View. 20

Appendix E

Pavement Condition - June, 1982 21

Appendix F

Work Plan 81-R-15. 23

ABSTRACT

Approximately 60 tons of bituminous mix modified with polyester fibers was produced and placed as a surface course on Route 12-A in Northfield, Vermont in August of 1981.

The polyester fibers were added to the mix at the rate of five pounds per ton or 0.25 percent of the total mix. No significant problems were encountered with the production or placement of the modified mix.

Field inspections through the first 10 months of service revealed 12 percent reflective cracking in the standard mix and 2 percent reflective cracking in the modified mix with nearly all of the latter occurring within an area where the overlay averaged 3/8 to 1/2 inch in thickness. In addition, crack formations in the standard pavement stopped abruptly at the perimeter of the fiber modified pavement at five locations.

The initial performance of the polyester fiber modified mix suggests that the material should be considered for further experimental use on one or more additional paving contracts.

INTRODUCTION

For the past few years, polyester fibers have been promoted for use in bituminous concrete mixes as a substitute for asbestos fibers which are no longer available due to health hazards. The polyester fibers reportedly reduce air voids, increase mix stability and reduce reflective cracking of new bituminous overlays. Suppliers propose that the use of fibers allows the placement of thinner overlays resulting in cost savings to the user.

In June 1981, the Vermont Agency of Transportation was offered 300 pounds of polyester fibers at no charge for a field evaluation. With the cooperation of District No. 6 Transportation Administrator Lawson and a local bituminous concrete mix supplier, Cooley Asphalt Paving Corporation, an experimental bituminous mix was batched and placed by District Maintenance forces in early August, 1981.

This report describes the production and placement of the modified mix and field performance results through the first 10 months of service.

PRODUCT INFORMATION

The polyester fibers recommended for use in bituminous concrete mixes can be produced by most textile mills in a variety of weights and lengths using a continuous melt spinning process. The material donated for experimental use in Vermont was BoniFibers, a registered trademark product supplied by KAPEJO, INC., 3 Pierce Road, Wilmington, Delaware 19803 (Phone 302 654-1915).

The supplier reports that the material has a specific gravity of 1.38 and a melting point over 480°F. The fibers have a breaking strength in excess of 70,000 psi, have a low water absorbency, do not cake in storage, and have excellent resistance to abrasion. The material does not cause any dermatological or other health problems as was the case with asbestos fibers.

BoniFibers are available in two lengths, 1/4 inch designated B and random cut fibers averaging 1/50 inch designated C. The B fibers are recommended for coarser mixes used for overlays and base courses. The C fibers are recommended for mixes used in curbs, bridge deck pavements and thin overlays.

The fibers are added to the mix at a rate of 2.5 pounds to 5.0 pounds per ton of mix. This amounts to 0.125% to 0.25% by weight of the total mix. BoniFibers are packaged in 2 mil polyethylene bags which melt at approximately 200°F thereby allowing the introduction of the unopened bags directly into the pugmill with the aggregate. The fibers are available in 5, 7½, and 10 pound units to obtain the proper addition rate with various batch sizes. A 30 second dry mix cycle is required to insure uniform distribution of the fibers. An additional 0.2% asphalt is also required to coat the fibers. Placement and compaction of the modified mix is achieved with conventional pavers and rollers.

BoniFibers B are currently available in 5, 7½, and 10 pound bags at a cost of $1.09, $1.07, and $1.05 per pound respectively. All prices are F.O.B. the KAPEJO, INC. warehouse in Milford, Delaware for the year 1982.

When BoniFibers are added at a rate of 5 pounds per ton of mix, the modified mix could be expected to cost a minimum of $7.00 per ton more than the standard bituminous concrete mix. The increase would include the cost of the fibers, freight at 25¢ per pound, 0.2 percent extra asphalt, and labor for adding the fibers to the mix.

The modified mix could be cost effective if it's performance is sufficient to extend pavement life or allow a 25 percent reduction in the pavement thickness as shown in the Manufacturer's Cost Saving Estimate in Appendix A on page 14.

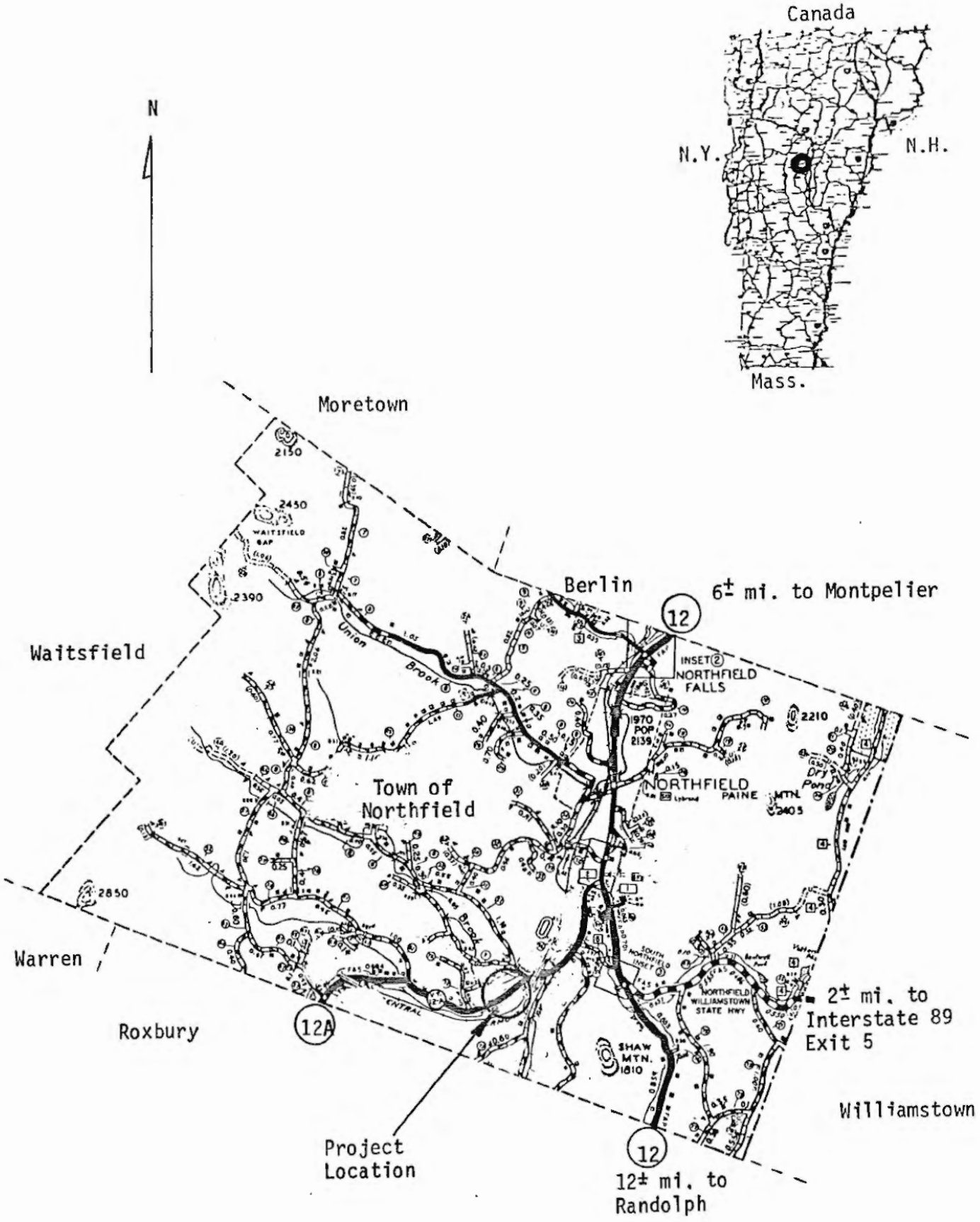


Figure 1

VT Rte. 12-A Northfield, Vt.

PROJECT DESCRIPTION & ROADWAY CONDITION

The modified and standard bituminous concrete mixes were placed on a 0.9 mile segment of Vermont Route 12A in the Town of Northfield. Paving began at Bridge No. 35, approximately 1.49 miles southwest of the intersection of Vermont Route 12 and proceed southerly 0.86 mile to a point just south of Bridge No. 32 over the Dog River.

The existing roadway was constructed during the period 1941 - 1947 with a 12 to 18 inch subbase and a treated gravel surface. Additional retreatments with blade mixes or bituminous seals were carried out in 1953, 1957, 1959, 1962, and 1965. The last treatment consisted of a 3/4 inch bituminous concrete pavement placed in 1970.

A detailed pavement condition survey was made on a 400 foot section of the project on August 11, 1981, two days before the new overlay was placed. The survey revealed an average of 990 lineal feet of cracks per 100 lineal feet of 22 foot wide roadway. Nearly all of the cracks were longitudinal, often occurring as a series of adjacent, parallel cracks at varing locations across the roadway. Raveling had occurred on a small percentage of the cracks with the result that the underlying treatment was occasionally visible. Wheel path rutting averaged 1/4 inch on both northbound and southbound lanes although maximum values did range up to 7/8 inch and 1 1/4 inch respectively. The pavement condition can be seen on pavement survey sheets, in Appendix B on pages 15 and 16 and in photos on pages 9 and 11.

Average daily traffic on this section of Route 12A was 840 vehicles in 1980 with an estimated 6 percent truck traffic.

MIX PRODUCTION AND TESTING

A type IV bituminous concrete mix was produced for the project on August 13, 1981 at the Cooley Asphalt Paving Corporation batch plant in Berlin, Vermont. The asphalt was an 85/100 penetration grade supplied by British Petroleum, Montreal, Quebec, Canada. The coarse aggregate consisted of crushed granite with 95 to 100 percent passing the 3/8 inch sieve while the fine aggregate included equal parts of natural sand and crushed granite.

The first six loads produced for the project were standard mix. The next six loads were modified with Type B fibers which were added at the rate of five pounds per ton or 0.25 percent of the total mix. The plants normal dry mix cycle was increased from 5 to 30 seconds to insure distribution of the fibers which were manually introduced into the pugmill.

The modified and standard mixes were tested for asphalt content, gradation, air void content, stability, flow and unit weight. Extraction tests revealed a 6.3 percent asphalt content in the modified mix as compared to 6.5 percent in the standard mix. The lower value was believed to be due to normal testing variance since the batch slip (ticket) print-out confirmed that an additional 0.2 percent asphalt was added to the modified mix as required. The modified mix also had a high air void content of 6.7 percent and a lower stability than the standard mix, 1061 vs 1464. Both the modified and standard mix produced Marshall flow values of 13.

A summary of the mix design and laboratory test results can be seen on pages 17 through 19.

PAVING OPERATION

Paving began about 8:30 AM under overcast skies with the ambient temperature at 63°F. The trucks were staggered within the 400 foot test section in order to have side by side and end to end areas for comparing the modified and standard mix. A plan view of the installation can be seen in Appendix D on page 20.

The thickness of the overlay varied with the contour of the old pavement surface. On the average, 1 3/8 inches was placed along the centerline while a minimum thickness of 3/8 inch was obtained between the wheelpaths on some segments due to excessive wheel path rutting. In many of the very thin areas, voids in the new overlay revealed portions of the underlying pavement.

Significant differences in color were noted between the two mixes with the fiber modified mix appearing brown much like the color of an asphalt emulsion as it begins curing. The variation in color remained for several weeks before fading under traffic.

Fibers were visible in the modified mix when close observations were made. A few clumps of asphalt coated fibers were also noted in the compacted pavement.

The modified mix did not present any problems with placement. At times it appeared to drag more than the regular mix but it also seemed to provide a smoother, denser surface texture following compaction with an 8 - 10 ton double axle steel wheeled roller. The modified mix also retained fewer roller marks.

No attempt was made to obtain pavement cores due to the overall thinness of the overlay.

Northbound lane prior to placement of the modified mix.

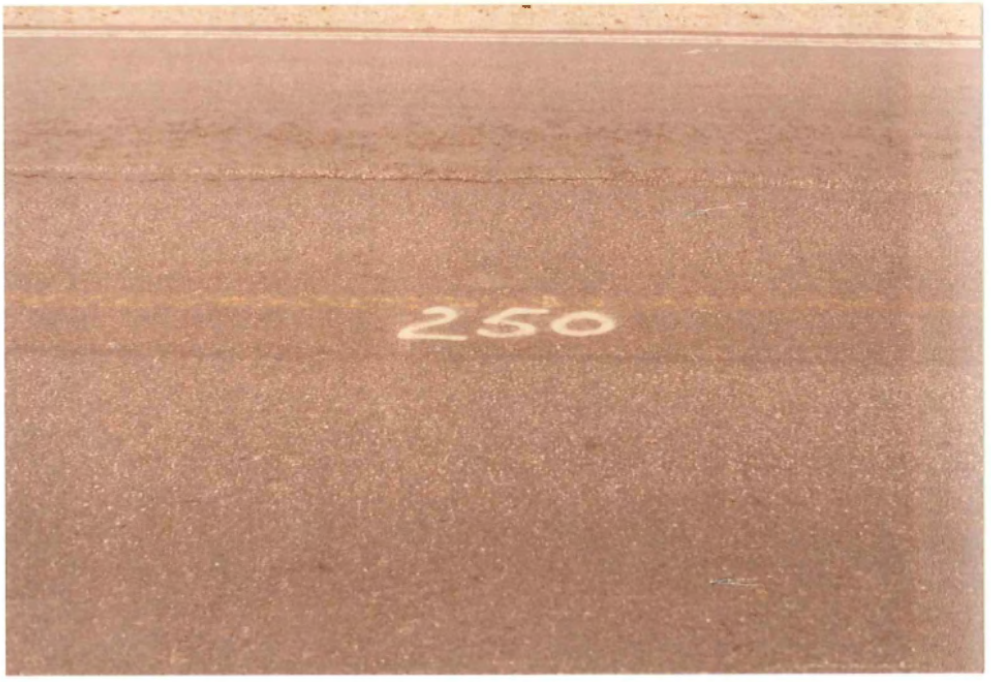
POST CONSTRUCTION OBSERVATIONS

On August 25, 1981, friction tests were taken on the project area using a locked wheel friction trailer. The measurements, taken in the left wheel path at a speed of 40 mph, averaged 46.5 on the fiber modified mix and 48.1 on the standard mix. The difference of 1.6 is not considered significant. The experimental and control pavements were inspected and photographed at various times through the first 10 months of service. Occasional cracks were first observed in February, 1982 and a detailed crack survey was conducted in June. The survey within the 400 foot test section revealed a total of 265 lineal feet of cracks in the standard pavement (12% of initial crack count) and 35 lineal feet of cracks in the fiber modified pavement (2% of initial

crack count). Nearly all of the cracks in the modified pavement were located within an area where the overlay averaged 3/8 to 1/2 inch in thickness. There was no evidence of raveling or loss of the experimental or standard mix adjacent to cracks or in thin areas where the underlying pavement remained visible. At two locations within the test section and at several other locations on the project, crack formations in the standard pavement stopped abruptly at the perimeter of the fiber modified pavement. The survey results can be seen in Appendix E on pages 21 and 22.

Crack Formation Retarded or Stopped In The Modified Mix

Original Pavement Condition at Station 250
Northbound Lane in Forground



June 1982 Pavement Condition at Station 250

Modified Mix Foreground - Standard Mix Background

SUMMARY

No significant problems were encountered in the production or placement of approximately 60 tons of bituminous mix modified with polyester fibers at the rate of 5 pounds per ton of mix.

Increasing the dry mix cycle from 5 to 30 seconds appeared to be sufficient to allow dispersal of the fibers although a few clumps of asphalt coated fibers were noted in the compacted pavement.

The modified mix appeared to drag more beneath the paver's screed but provided a smoother surface texture with fewer roller marks than the standard mix following completion of compaction.

Twelve percent reflective cracking occurred in the standard mix and 2 percent reflective cracking occurred in the fiber modified mix through the first 10 months of service. Nearly all cracks in the modified mix occurred within an area where the overlay averaged 1/2 inch or less in thickness. Crack formations in the standard mix stopped abruptly at the perimeter of the fiber modified pavement at several locations.

RECOMMENDATIONS

Monitoring should continue on the fiber modified pavement to determine long term performance of the material.

The polyester fiber modified mix should be specified for use on one or more additional paving contracts. The evaluation should include the use of varied pavement thicknesses to determine if the modified pavement can provide cost savings by providing equal or longer service life when applied in thinner courses.

Costs of Overlaying 10 Square Yards with Hot-Mix Asphalt Concrete

(density of 142 pounds/cubic foot)

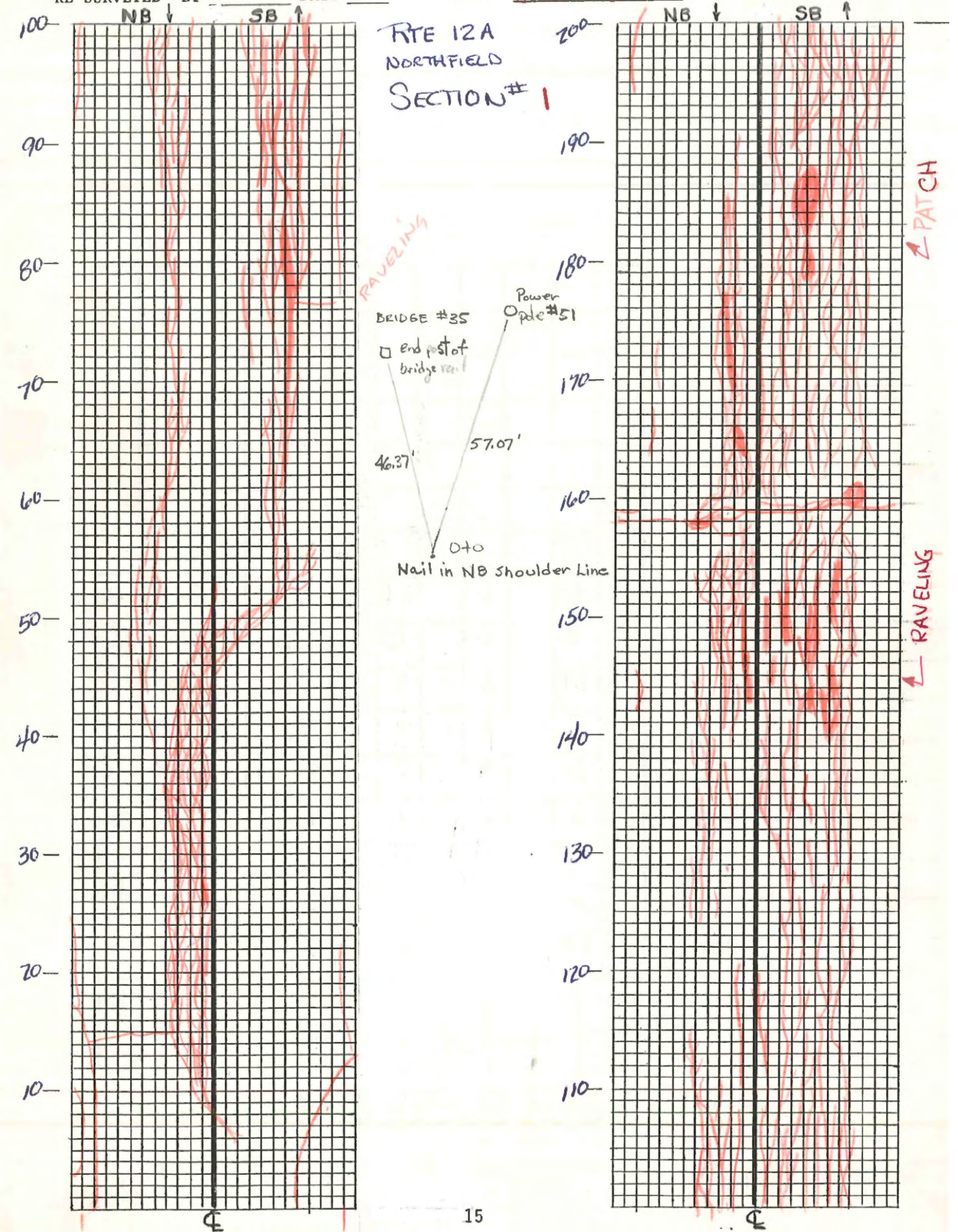
	When fiber-free hot-mix costs:			
	$28.00 ton	$30.00 ton	$32.00 ton	$35.00 ton
3/4" THICK OVERLAY REINFORCED WITH BONIFIBERS*				
(a) 0.4 tons of hot-mix	$11.20	$12.00	$12.80	$14.00
(b) 2 pounds of BoniFibers @ 1.06/pound	2.12	2.12	2.12	2.12
(c) Freight @ 25¢/pound for shipping BoniFibers	.50	.50	.50	.50
(d) Labor @ $10/hour for adding BoniFibers to mixer	.01	.01	.01	.01
(e) 0.2% extra asphalt @ $170/ton for coating BoniFibers	.13	.13	.13	.13
(f) 25% profit (on b, c, d & e) for the contractor	.69	.69	.69	.69
Total cost of fiber-reinforced overlay	14.65	15.45	16.25	17.45
Cost of 1" thick fiber-free overlay (0.533 ton)	14.92	15.99	17.06	18.66
Initial Saving by Reinforcing with BoniFibers	$0.27	$0.54	$0.81	$1.21
1-1/8" THICK OVERLAY REINFORCED WITH BONIFIBERS				
(a) 0.6 tons of hot-mix	$16.80	$18.00	$19.20	$21.00
(b) 3 pounds of BoniFibers @ $1.06/pound	3.18	3.18	3.18	3.18
(c) Freight @ 25¢pound for shipping BoniFibers	.75	.75	.75	.75
(d) Labor @ $10/hour for adding BoniFibers to mixer	.02	.02	.02	.02
(e) 0.2% extra asphalt @ $170/ton for coating BoniFibers	.20	.20	.20	.20
(f) 25% profit (on b, c, d & e) for the contractor	1.04	1.04	1.04	1.04
Total cost of fiber-reinforced overlay	21.99	23.19	24.39	26.19
Cost of 1-1/2" thick fiber-free overlay (0.8 ton)	22.40	24.00	25.60	28.00
Initial Saving by Reinforcing with BoniFibers	$0.41	$0.81	$1.21	$1.81
1-1/2" THICK OVERLAY REINFORCED WITH BONIFIBERS				
(a) 0.8 tons of hot-mix	$22.40	$24.00	$25.60	$28.00
(b) 4 pounds of BoniFibers @ $1.06/pound	4.24	4.24	4.24	4.24
(c) Freight @ 25¢/pound for shipping BoniFibers	1.00	1.00	1.00	1.00
(d) Labor @ $10/hour for adding BoniFibers to mixer	.02	.02	.02	.02
(e) 0.2% extra asphalt @ $170/ton for coating BoniFibers	.27	.27	.27	.27
(f) 25% profit (on b, c, d & e) for the contractor	1.38	1.38	1.38	1.38
Total cost of fiber-reinforced overlay	29.31	30.91	32.51	34.91
Cost of 2" thick fiber-free overlay (1.065 tons)	29.82	31.95	34.08	37.28
Initial Saving by Reinforcing with BoniFibers	$0.51	$1.04	$1.57	$2.37

NOTE: Freight costs from the fiber warehouse in Milford, Delaware, are in the range of 8¢ to 40¢ per pound - depending on amount and distance shipped. Approximately costs have been 40¢ per pound for only 150 pounds shipped 3000 miles, and 8¢ per pound for 6000 pounds shipped 400 miles. Of course, these are direct functions of miles only or of weight only.

*Registered Kapejo Trademark

ORIG. SURVEY BY PC DATE 8/11/81 PAVEMENT CONDITION SURVEY APPENDIX B

RE-SURVEYED BY _____ DATE _____ PROJECT Bow-Fibers



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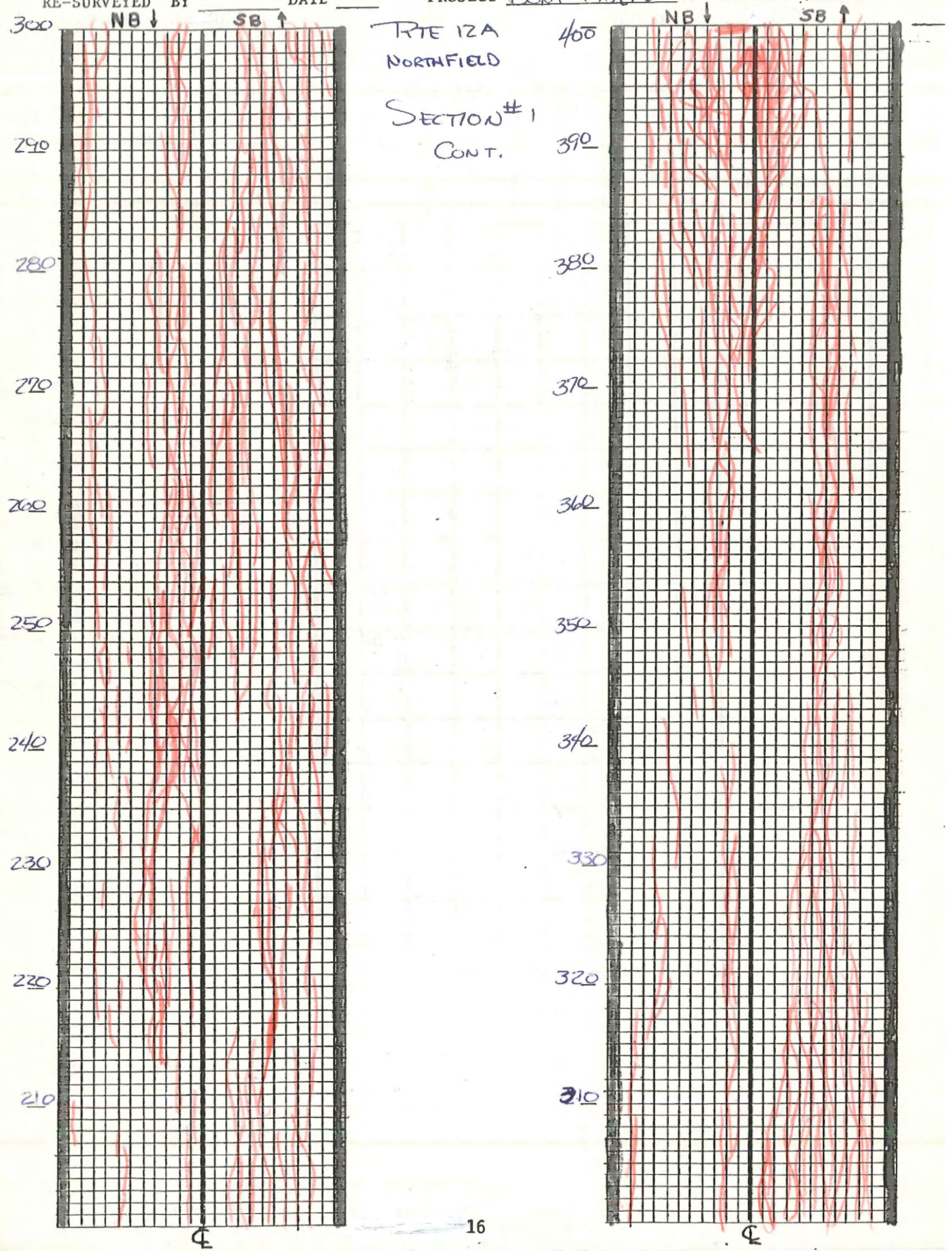
RE-SURVEYED BY _____ DATE _____

PAVEMENT CONDITION SURVEY
PROJECT BONI-FIBERS

APPENDIX B

TRTE 12A
NORTHFIELD

SECTION #1
CONT.



APPENDIX C

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - BITUMINOUS CONCRETE SUBDIVISION

№ 1858

Design of Bituminous Concrete Mixtures

Town State of Vt. Dist #6 Project No. Various Locations

Gentlemen:

In accordance with the specification requirements for the above project I submit the following job mix formula:

Pavement Type #6 III Produced By: Cooley Asphalt Paving Plant Location Berlin, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200
Nat Sand	29.5						100	94	85	71	49	26	7
Gr. Sand	29.5						100	98	80	53	23	15	2
3/8"	41					100	98	29	7				
Resultant	100					100	99	69	51	36	24	12	2.7

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200
S	59							100	80	63	43	25	5.5
2	41					100	98	26	2				
3													
4													
5													
Resultant	100					100	99	70	48	37	25	15	3.3

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	3702	2850				448	7,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula						100	99	69	50	38	26	16	3.5	6.4
Job Aim		/	/	/	/	100	95/100	63/75	46/54	34/42	22/30	13/21	2/5	6.0/6.8
Specification Limits		/	/	/	/	100	95/100	62/80	39/60	24/45	14/25	6/24	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Cooley Asphalt Paving - Websterville	AC-5:
Fine: Granite Sand - Cooley - Websterville Nat. Sand - Thunder Road Pit - Barre Town	AC-10: Other: 85-100 BP Canada

Mixing Times — Dry: 5 Wet: 35 Total: 40 Temperature: 280° F ± 20°

Submitted by: [signature] (signature) Date: 6-9-81

Company Cooley Asphalt Paving Corp. Title Treasurer

FOR STATE OF VERMONT USE ONLY

Approved ✓ Rejected

Comments:

Signature Charles E. Jerd Title Bituminous Concrete Supervisor

Date June 10, 1981

RECEIVED
JUN 10 1991
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TA 556 Rev. 500 Dup. 5/79

TA 183A Rev. 1M 6/81

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Central Files
Jerd
Aldrich
Lawson
~~Frascoia~~

APPENDIX C

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Materials and Research Division
Montpelier, Vermont 05602

REPORT ON SAMPLE OF BITUMINOUS CONCRETE

Report August 19, 1981

Laboratory No. D81 0871 Tested By P. Beyor

Name Bituminous Concrete Pavement - Item 406.25

Identification Marks Job Sample F-W-3

Submitted by P. Beyor Title PFP Address

Sampled 8/13, 19 81 Received 8/13, 19 81

Sample from truck @ plant Slip No. 80874 Time 8:20

Quantity Represented 60 tons

Source of Material Cooley - Berlin

Location used or to be used District #6 - VT 12A

Examined for Item 406.02(b) type IV with Fibers

TEST RESULTS

GRADATION - % PASSING

	REPORTED	JOB AIM
1"		
3/4"		
1/2"		100
3/8"	100	95-100
No. 4	67	63-75
No. 8	52	46-54
No. 16	42	34-42
No. 30	31	22-30
No. 50	18	13-21
No. 200	4	2-5

BITUMEN
% BY WGT. 6.3 6.0-6.8

% AIR VOIDS	6.7
MARSHALL FLOW	13
MARSHALL STABILITY	1061

CORRECTIVE ACTION:

COMMENTS:

This material is 1% high passing the No.30 sieve and 1.7% high on Air Voids for Item 406.02(b) Type IV with Fibers

S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson /RFN

R. F. Nicholson, P.E., Materials & Research Engineer

sel

TA 183A Rev. 1M 6/81

APPENDIX C

5
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Jerd
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STATE OF VERMONT
AGENCY OF TRANSPORTATION

Materials and Research Division
Montpelier, Vermont 05602

REPORT ON SAMPLE OF BITUMINOUS CONCRETE

Report August 19, 19 81

Laboratory No. D81 0870 Tested By P. Beyor

Name Bituminous Concrete Pavement - Item 406.25

Identification Marks Job Sample F-WO-1

Submitted by P. Beyor Title PFP Address

Sampled 8/13, 19 81 Received 8/13, 19 81

Sample from truck at plant Slip No. 80866 Time 7:41

Quantity Represented

Source of Material Cooley - Berlin

Location used or to be used District #6 - Vt. 12A

Examined for Item 406.02(b) type IV

TEST RESULTS

GRADATION - % PASSING

	REPORTED	JOB AIM
1"		
3/4"		
1/2"	100	100
3/8"	99	95-100
No. 4	68	63-75
No. 8	51	46-54
No. 16	40	34-42
No. 30	29	22-30
No. 50	17	13-21
No. 200	4	2-5

BITUMEN
% BY WGT. 6.5 6.0-6.8

CORRECTIVE ACTION:

% AIR VOIDS 5.8

MARSHALL FLOW 13

MARSHALL STABILITY 1464

COMMENTS:

This material is 0.8% high on air voids for item 406.02(b) Type IV.

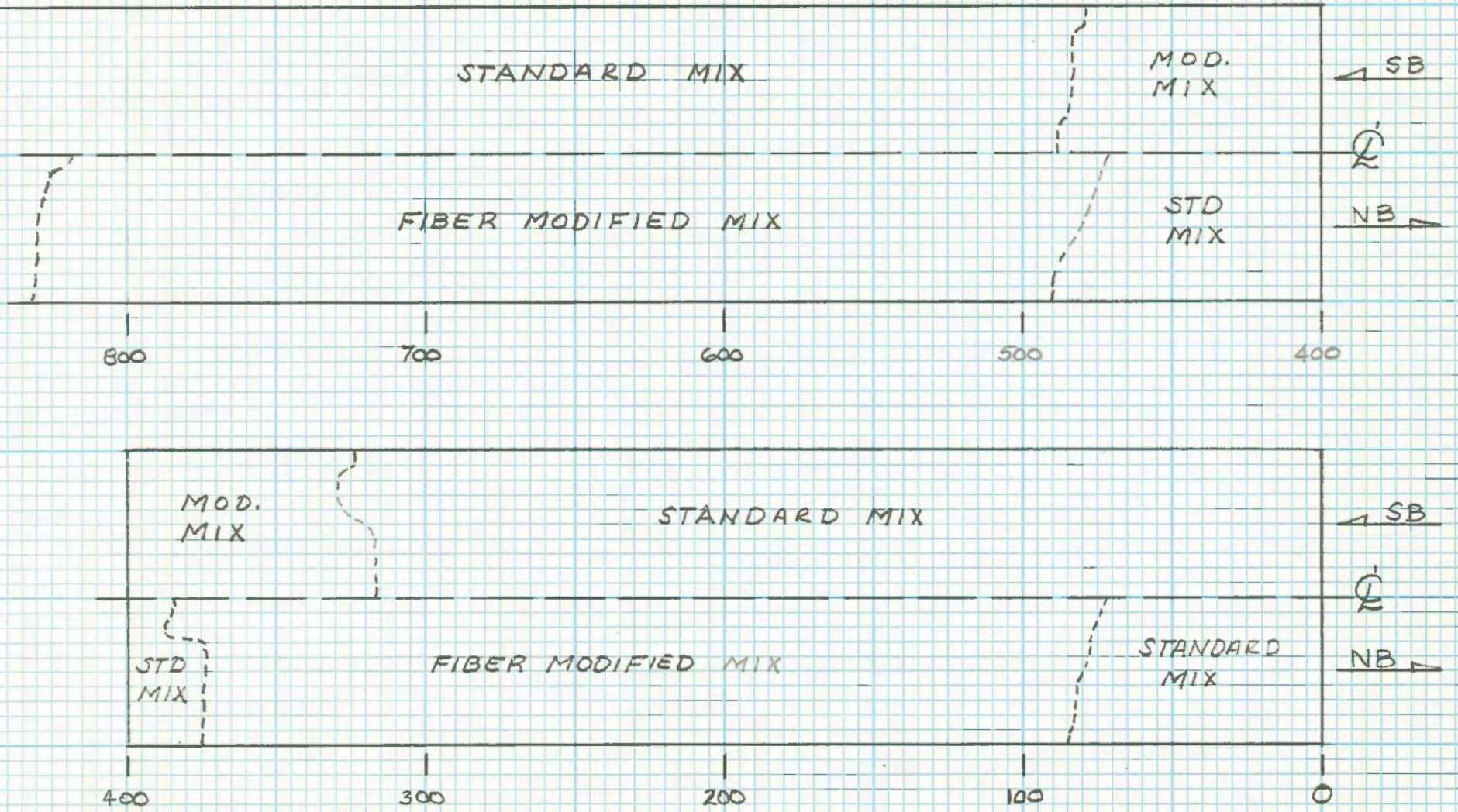
S. J. Cage, P.E., Chief Engineer

By: R. F. Nicholson 8/17
R. F. Nicholson, P.E., Materials & Research Engineer

sal

VERMONT ROUTE 12A BONIFIBERS FIELD TEST

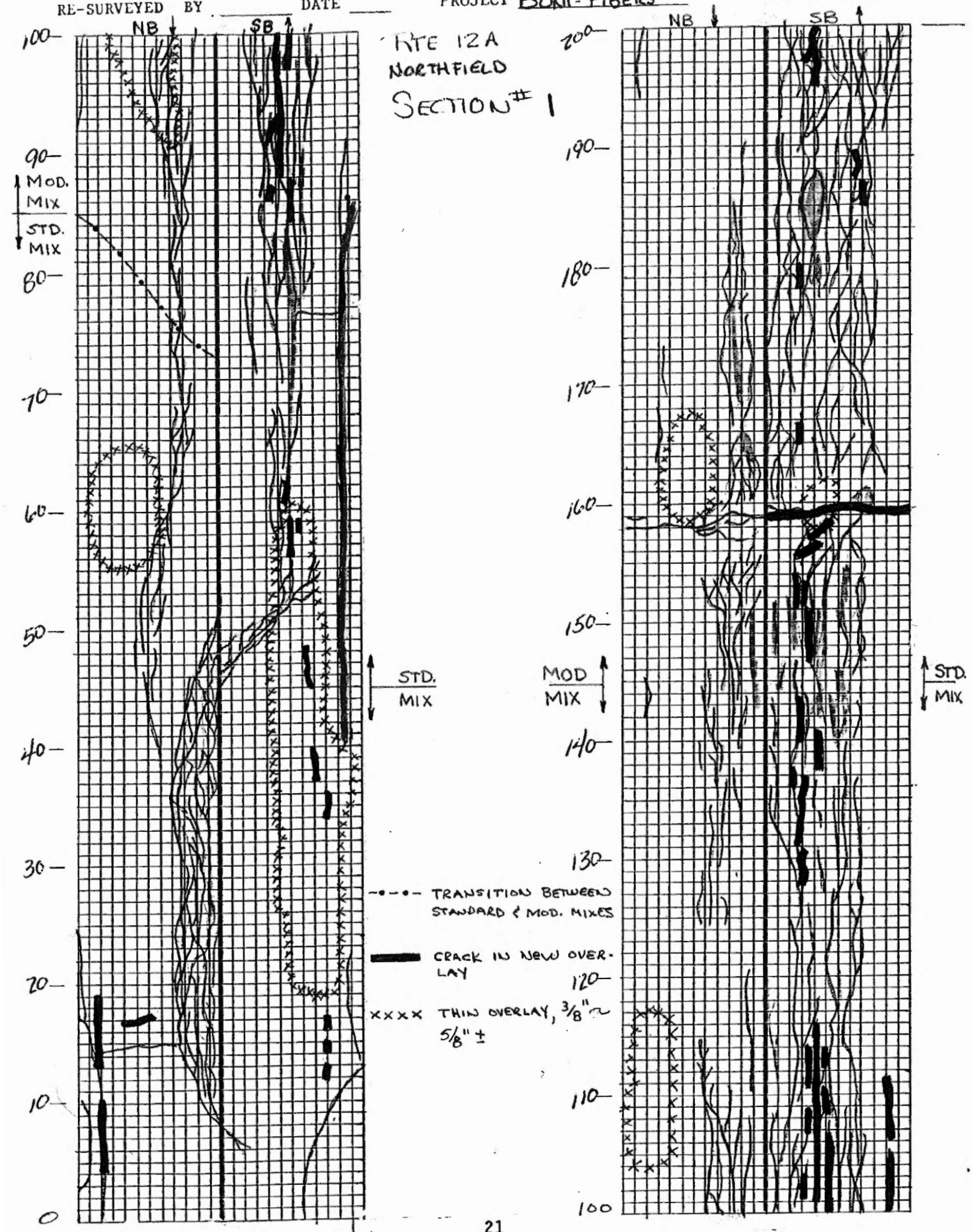
8/13/81
2F



STATION 0+0 STARTS OPPOSITE SOUTHERLY SIDE OF BRIDGE NO. 47 ON TOWN HWY NO. 8
STATION 468 EQUALS RTE 12A MILEMARKER LOCATION 0.280

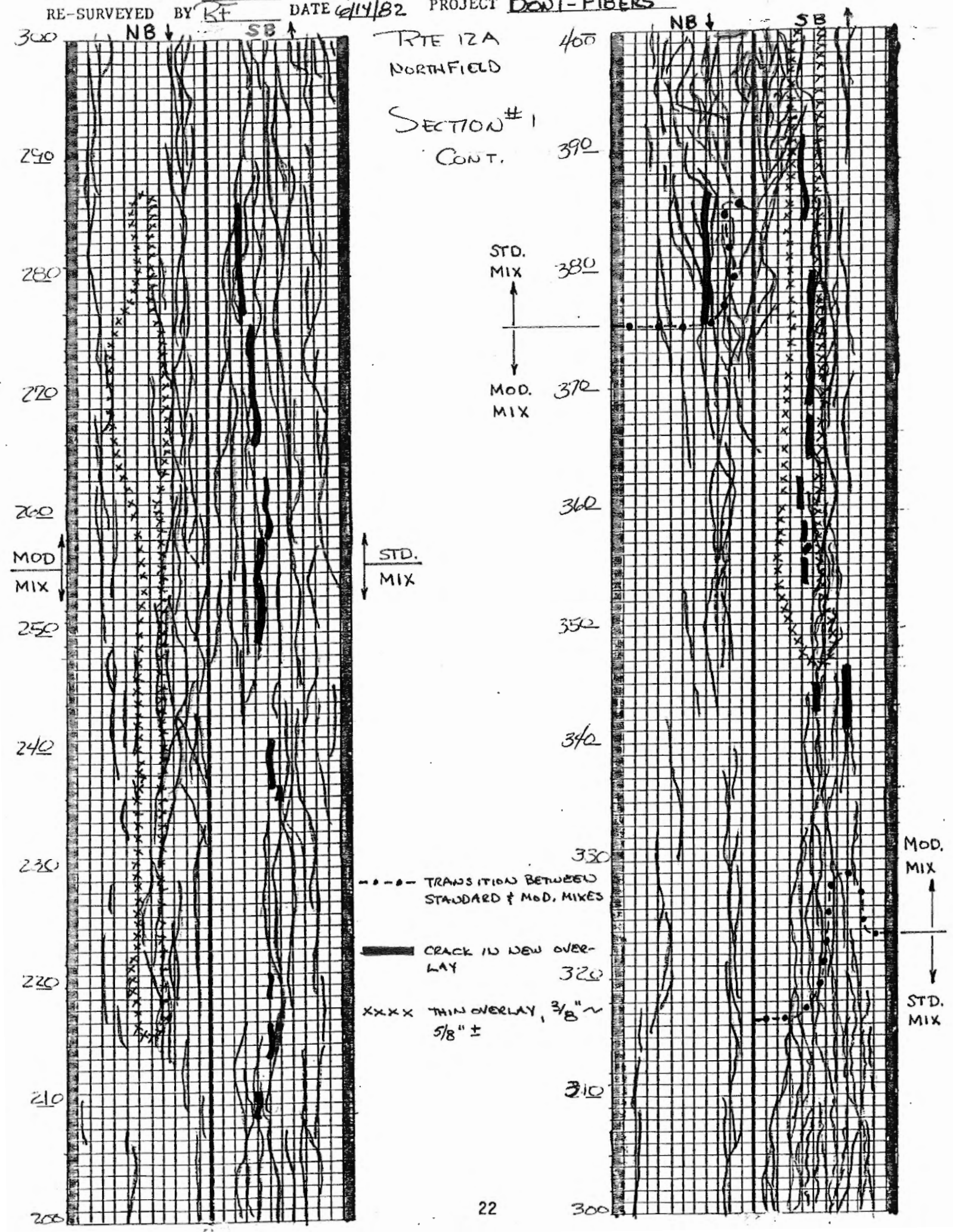
ORIG. SURVEY BY PC DATE 8/14/81 PAVEMENT CONDITION SURVEY
RE-SURVEYED BY _____ DATE _____ PROJECT "BONI-FIBERS"

RTE 12A
NORTHFIELD
SECTION # 1



ORIG. SURVEY BY PC DATE 8/11/81
RE-SURVEYED BY RF DATE 6/14/82

PAVEMENT CONDITION SURVEY
PROJECT "BOND-FIBERS"



TA 564 Rev. 4/79

Prepared By: R. Frascoia
Date: 8/12/81
Sheet 1 of 2

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

APPENDIX F

PRODUCT EVALUATION

Work Plan No. 81-R-15

Product BONI FIBERS B

Manufacturer KAPEJO, INC.
3 Peirce Road
Wilmington, Del. 19803

~~Distributor~~ Representative Boni Philip Martinez, P.E.
3 Peirce Road
Wilmington, Del. 19803
Phone: 302-654-1915

Evaluation Requested By Mr. Martinez Date July 13, 1981

Date Evaluation Required ASAP Date Product Information Received 7/13/81

Date and Quantity of Samples Received 8/10/81 300 lbs.

Purpose of Evaluation To determine if the performance of a thin bituminous overlay is improved with the addition of polyester fibers (Boni Fibers).

Proposed Tests Compare the initial values and field performance of Type IV Bituminous Concrete Pavement, with and without Boni Fibers placed as a 3/4 inch overlay on Rte. 12A in the Town of Northfield at MM 0220± to 0300±. The evaluation shall include the following:

1. Document the condition of the existing pavement at several locations with photography and detailed crack surveys.
2. Conduct plant mix inspection on modified and control mixes for asphalt content, gradation, air voids, stability and flow.

(continued on sheet 2)

Proposal Discussed With N. Danforth, E. Chaffee P. Corti Projected Manpower Requirements 10 mandays-1981 3 mandays yearly thereafte

Evaluation To Be Conducted By Research & Development Subdivision

Proposed Starting Date 8/13/81 Estimated Completion Date 8/86

Approval/Disapproval by Materials & Research Engineer R.J. Nichols 8/13/81

Comments by Materials & Research Engineer

Materials & Research Division
Agency of Transportation
Date Typed: August 13, 1981

3. Monitor paving operation and note locations where modified mix is placed.

4. Obtain field cores of the completed pavement for percent compaction and recovered asphalt penetration values.

5. Inspect the test sections each spring and fall until valid conclusions can be drawn on the performance of the fiber modified pavement.